

RAFT

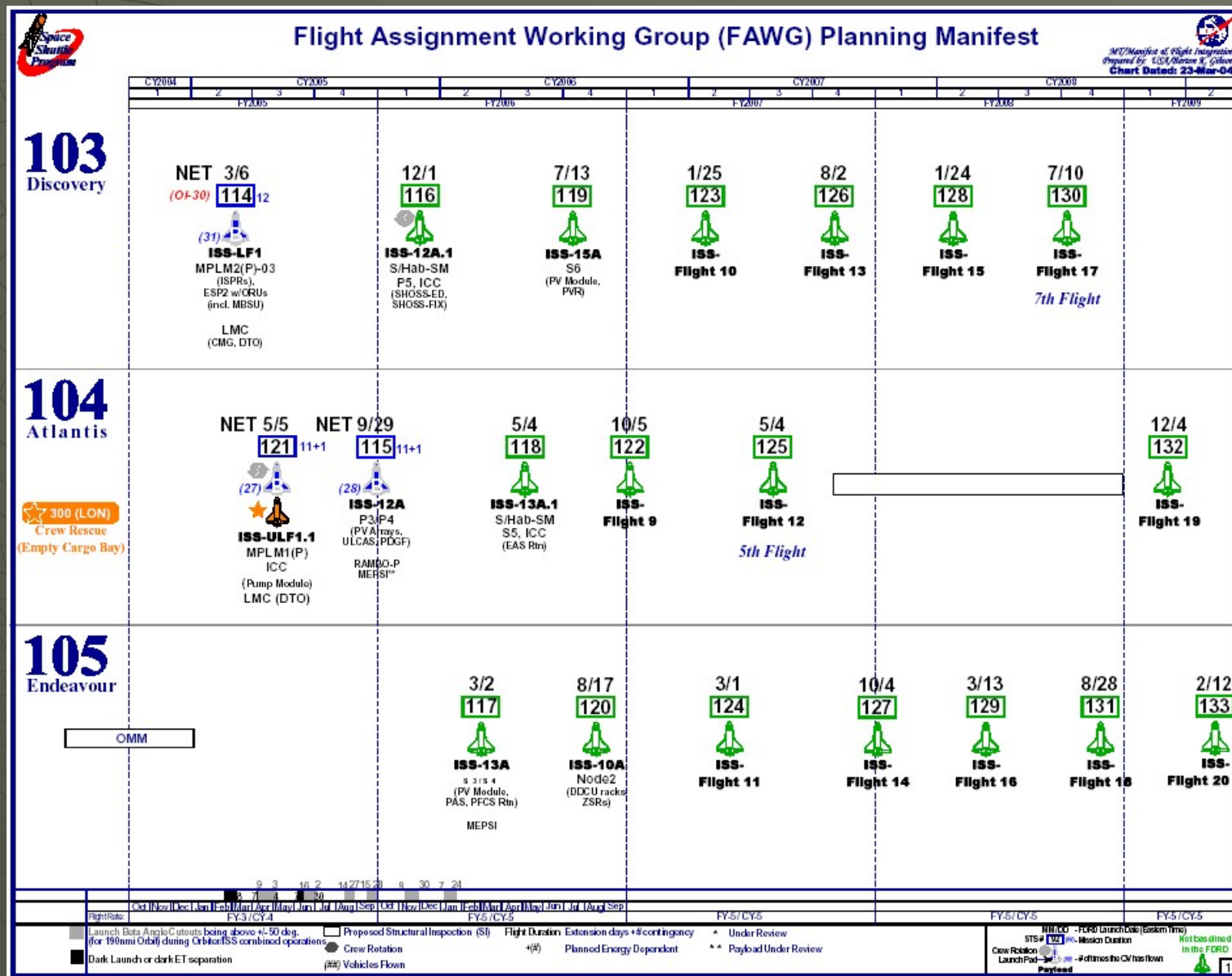
Radar Fence Transponder

Bob Bruninga, US Naval Academy Satellite Lab

AMSAT Symposium 10 Oct 2004



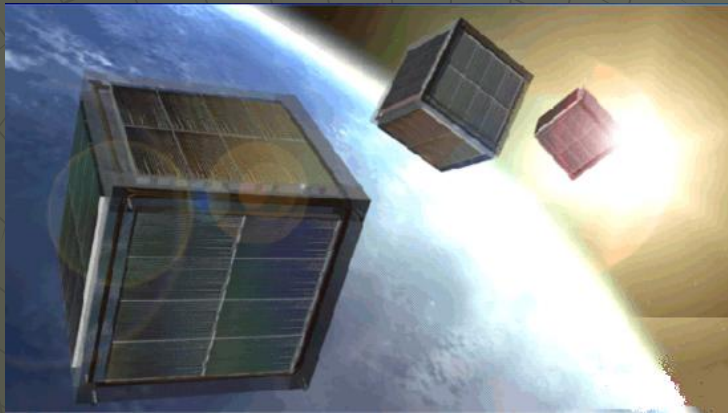
Shuttle Manifest: 2004 - 2008



Background

30 to 50 in Construction

How to Track them???



AIAA/
USUSmall
Sat
Conference

30% of
papers were
for PICO,
NANO and
CUBEsats

All smaller
than 10 cm



Mission Statement

The mission of RAFT is to:

- ♦ provide the Navy Space Surveillance, or NSSS, radar fence with a means to determine the bounds of a constellation of PicoSats otherwise undetectable by the radar fence
- ♦ to enable NAVSPASUR to independently calibrate their transmit and receive beams using signals from RAFT.

This must be accomplished with two PicoSats, one that will actively transmit and receive, and one with a passively augmented radar cross-section.

Additionally, RAFT will provide experimental communications transponders for the Navy Military Affiliate Radio System, the United States Naval Academy's Yard Patrol crafts, and the Amateur Satellite Service.

NSSS Radar Fence

Nm11e1024
3248.60N
09527.00W
TZ = 1000

1122 ToGo: S8M P56
No SAT being tracked
Mde-J 146.520 446
EL rings L 400 km
Path: Voice
az000:358

Move cursor to your
(shift)arrows, NumLock off and
(ctrl)PgDn. Then preSAT-TRAK

This is an APRStk plot showing
RS13 just crossing the Fence.
When the ISS crosses, anyone
should be able to hear it.

The NAVSPASUR fence is only 0.5
degrees wide so a LEO satellite
passes through it in about 2 secs

The 0.5 deg wide beam is shown not to scale. It
is only about 8 mi wide at 1000 mi from the site



RAFT1 and MARScom

RAFT1 Satellite

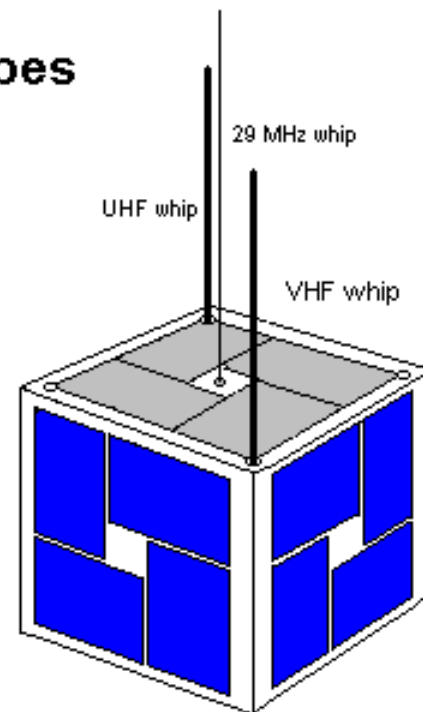
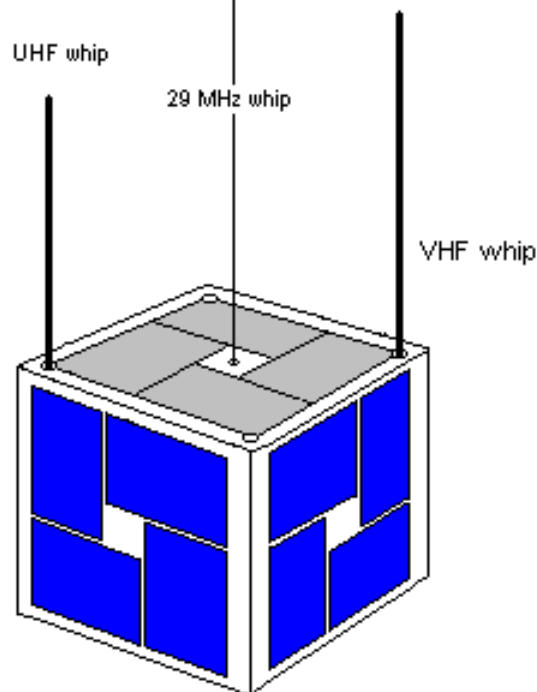
5" cubes

Downlink:

145.825 MHz Audio with both
AX.25 Packet and PSK-31 signals

Uplinks:

29.4 MHz linear PSK-31
435.275 AX.25 Packet



MARScom

Power Budget:

1 Watt orbit average DC power

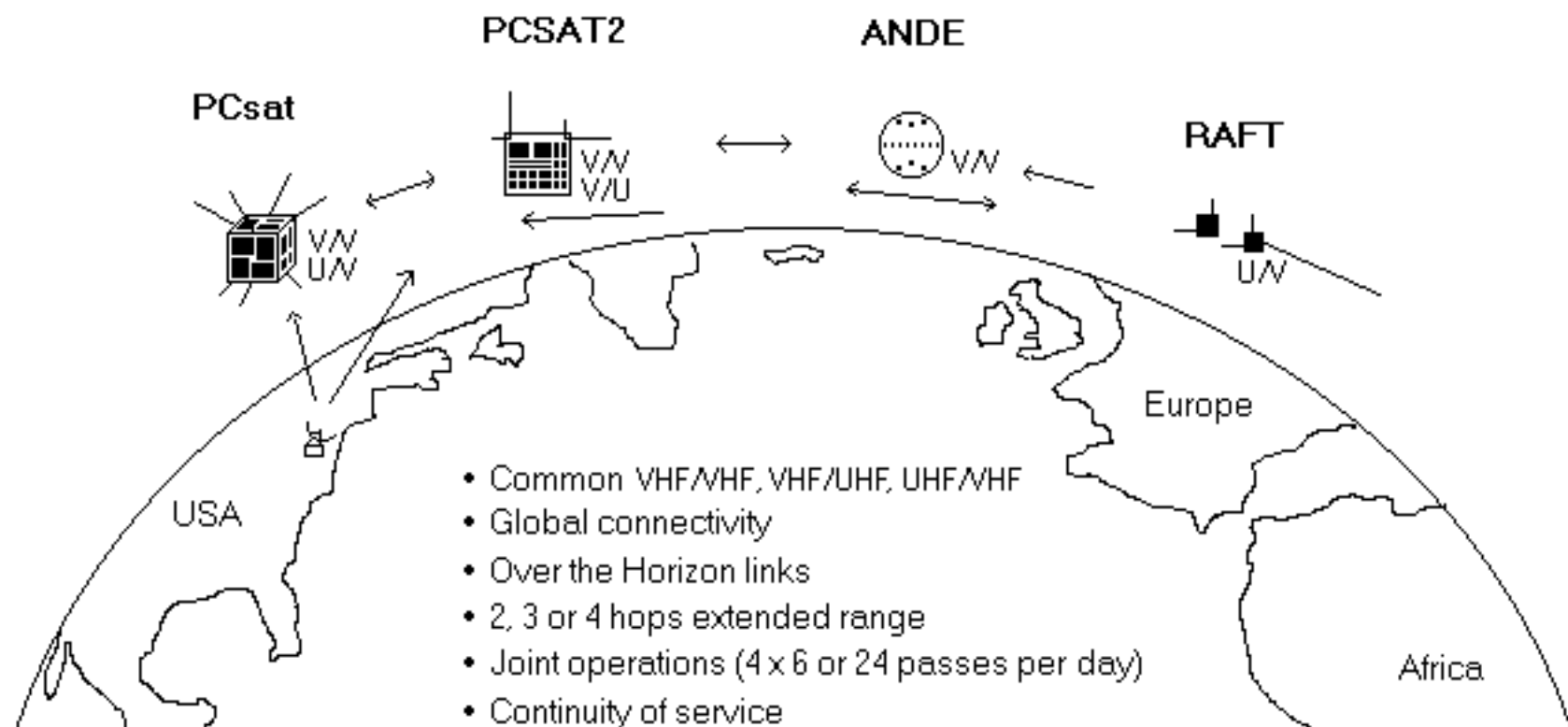
Link Budget:

10W UHF AM xmtr Voice uplinks
Downlink to any HF receiver
Omni Antennas for ground user

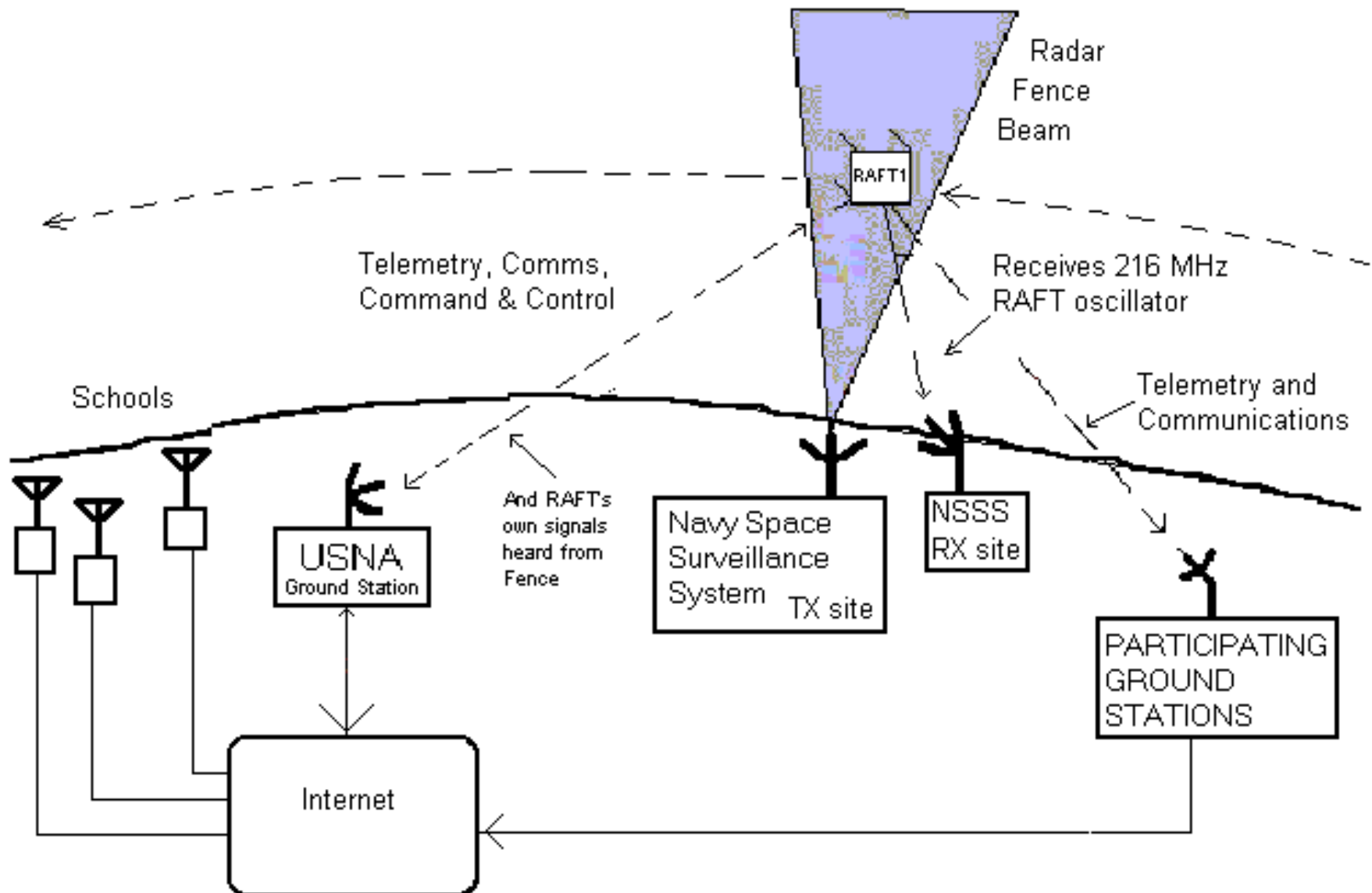
Channels:

UHF AM uplink
VHF FM uplink
HF SSB downlink

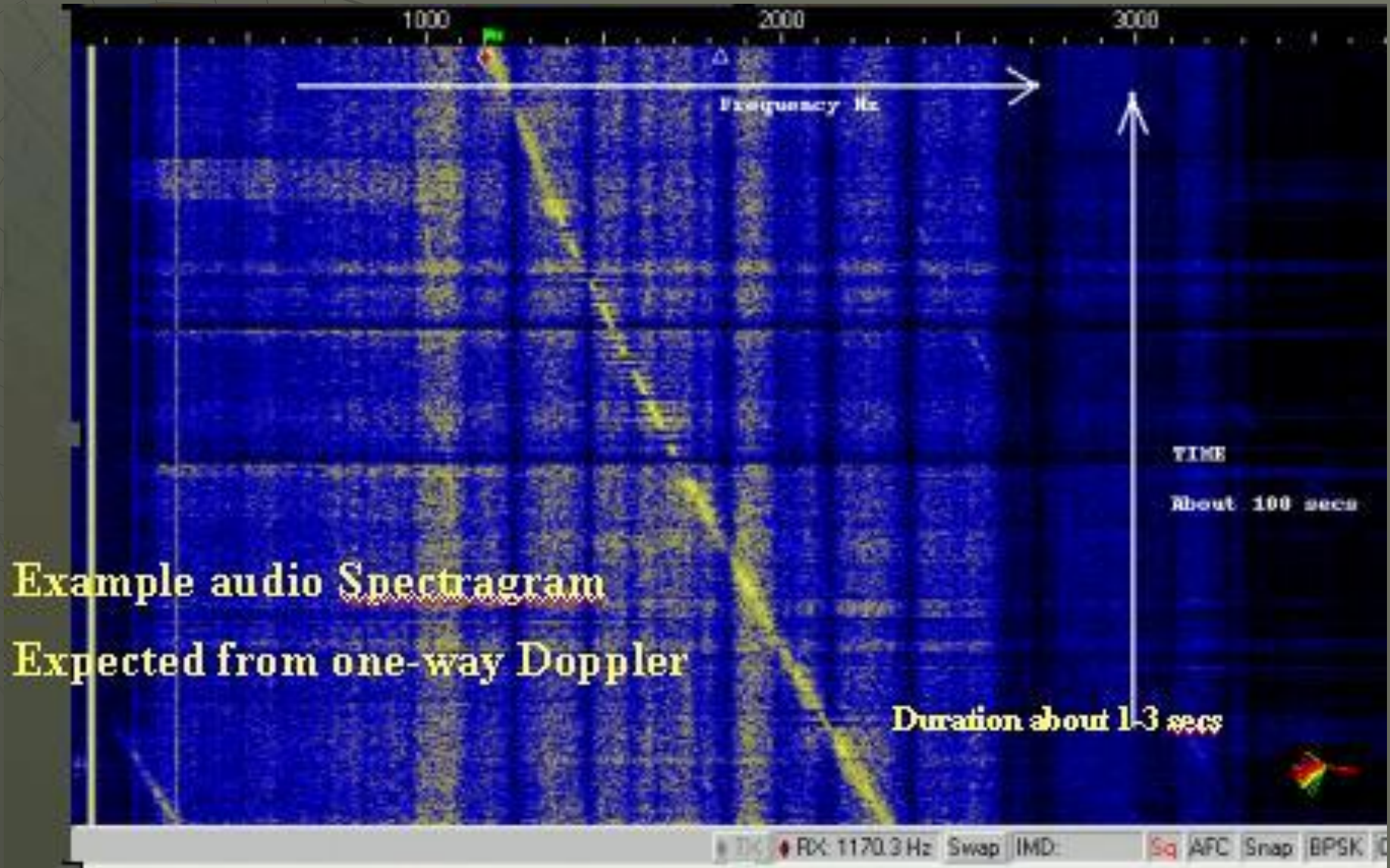
Constellation Operation of USNA Satellites



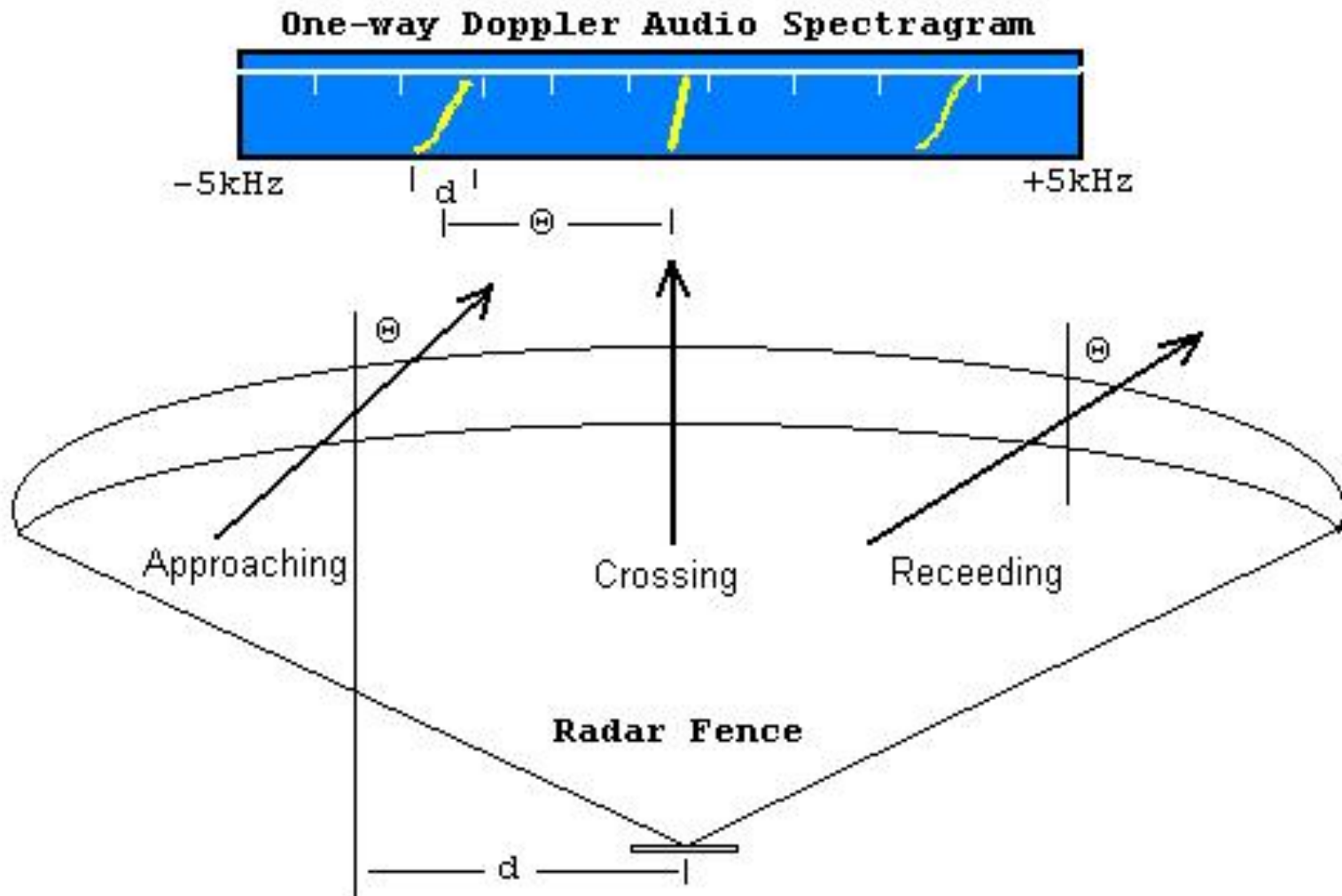
RAFT1 Mission Architecture



Audio Spectrogram

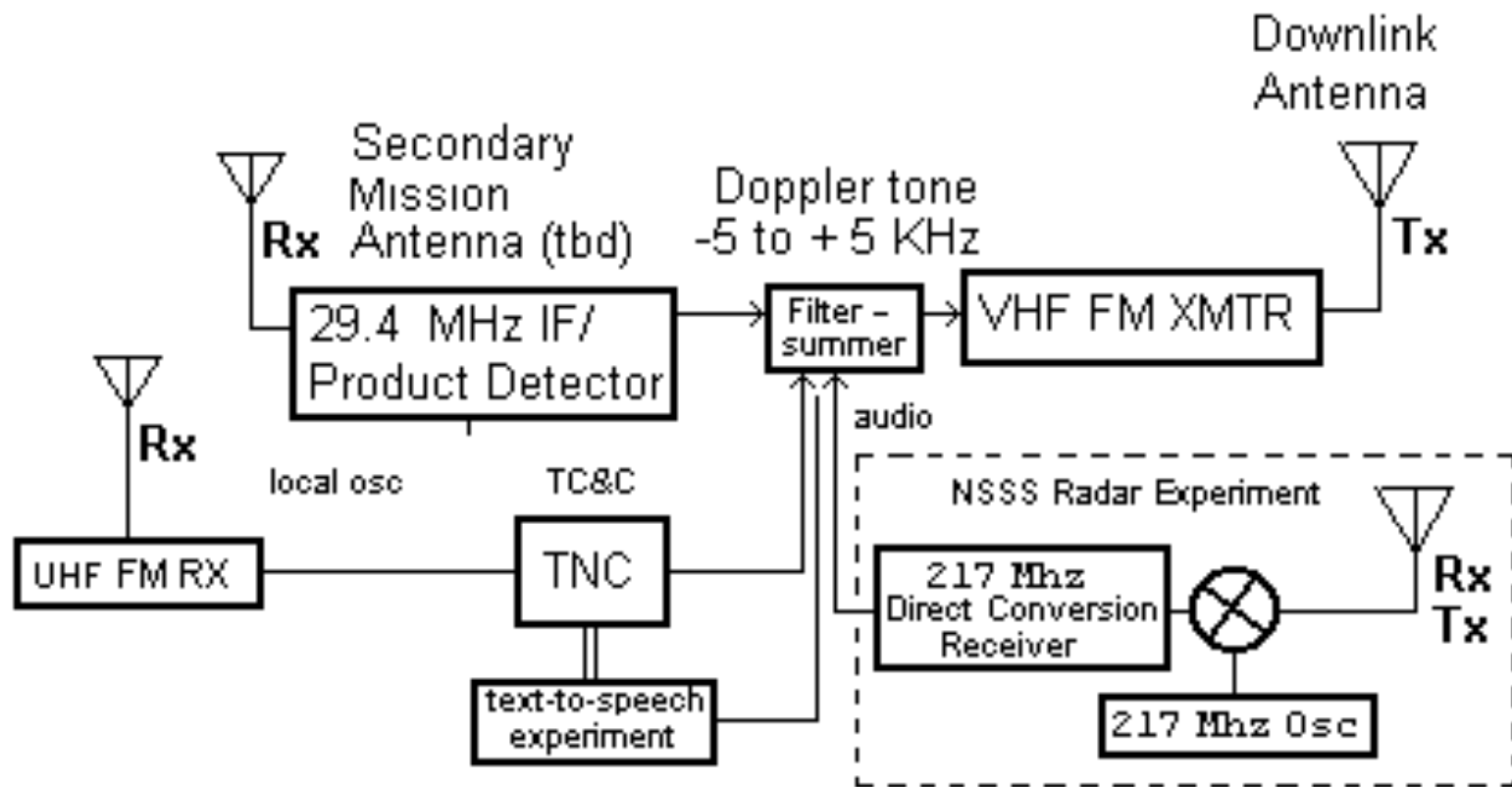


Pass Geometry

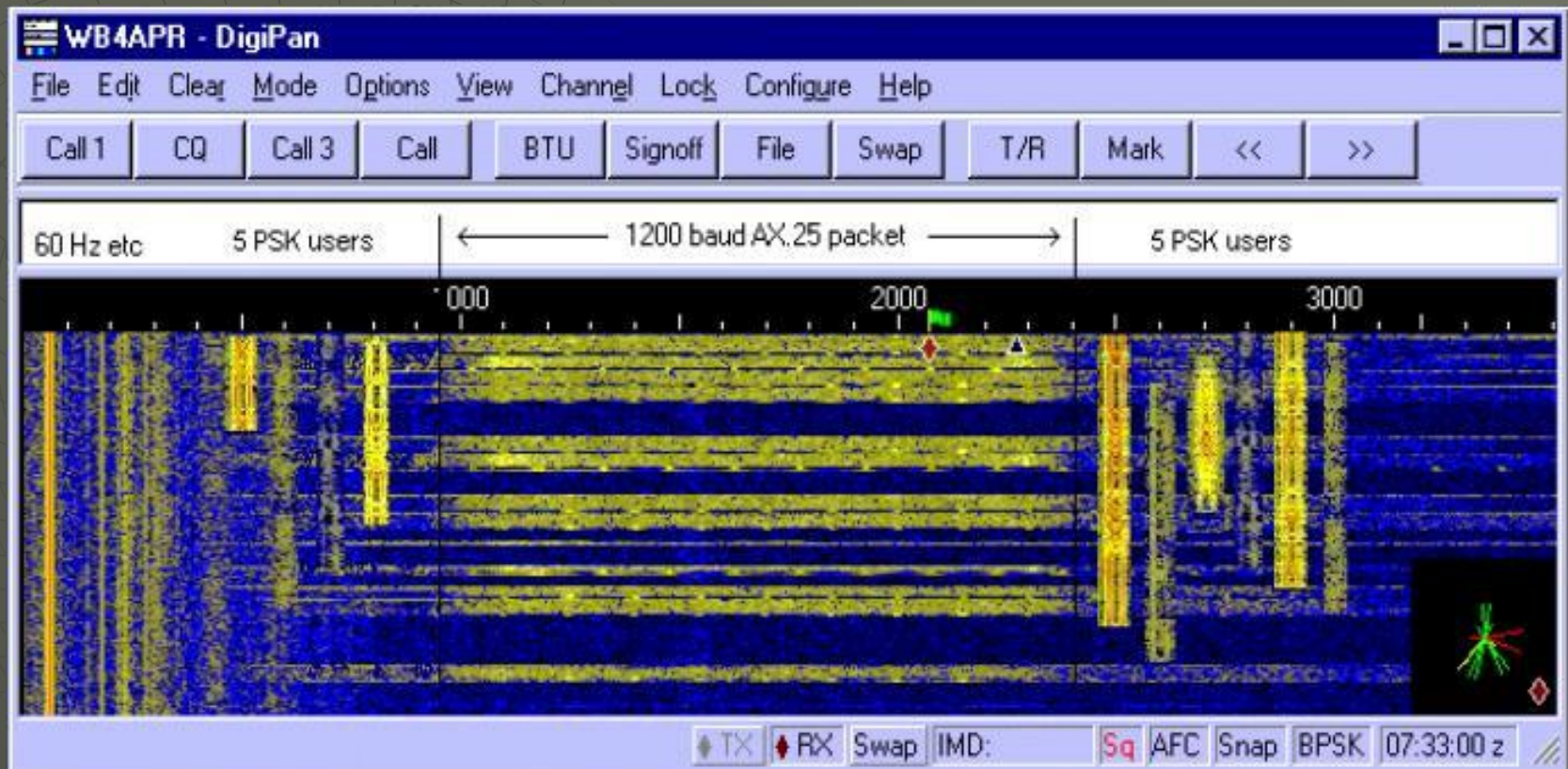


Raft1 Block Diagram

RAFT1 Radar Fence Transponder

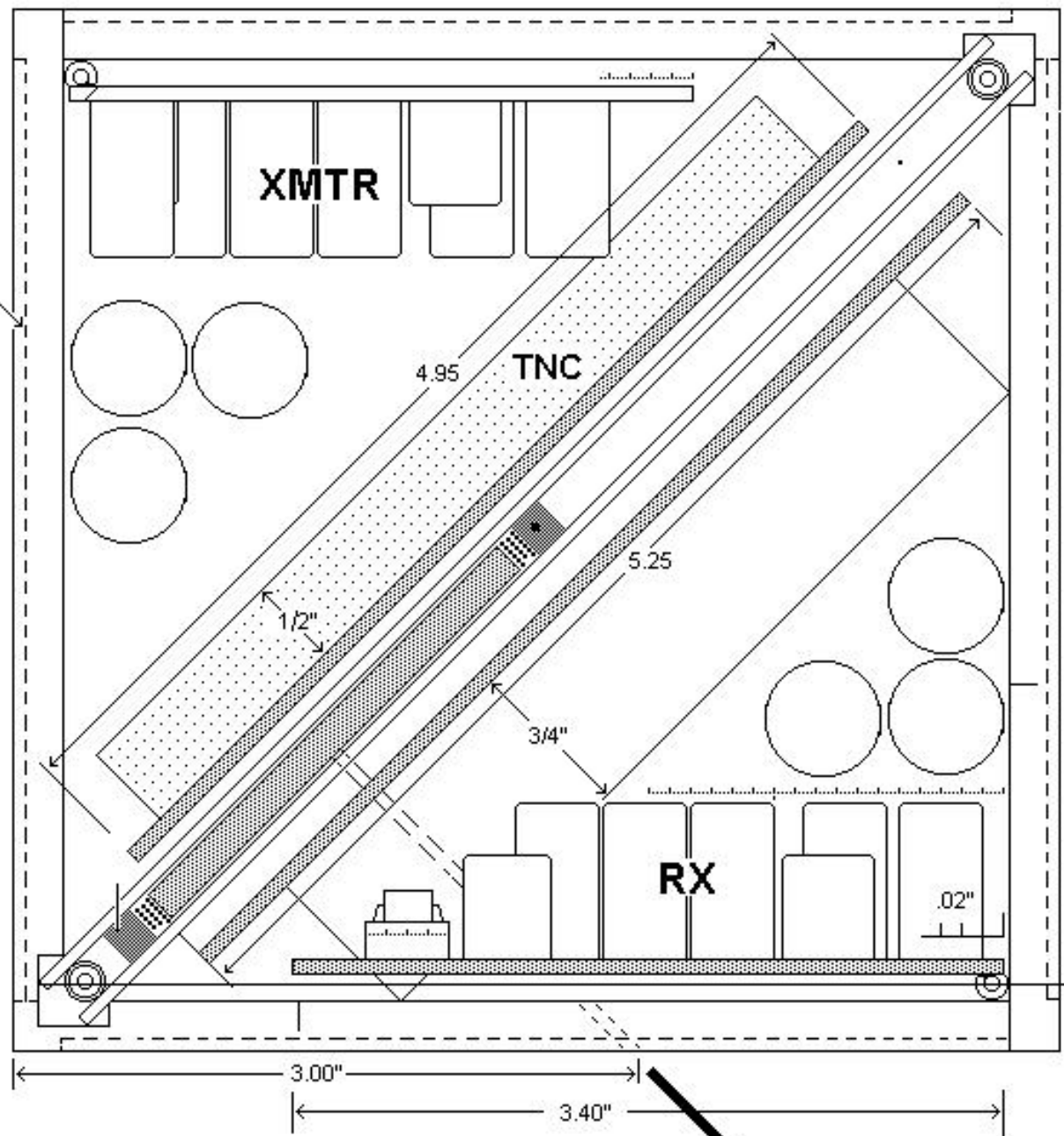


RAFT1 Comms and Multiplexing

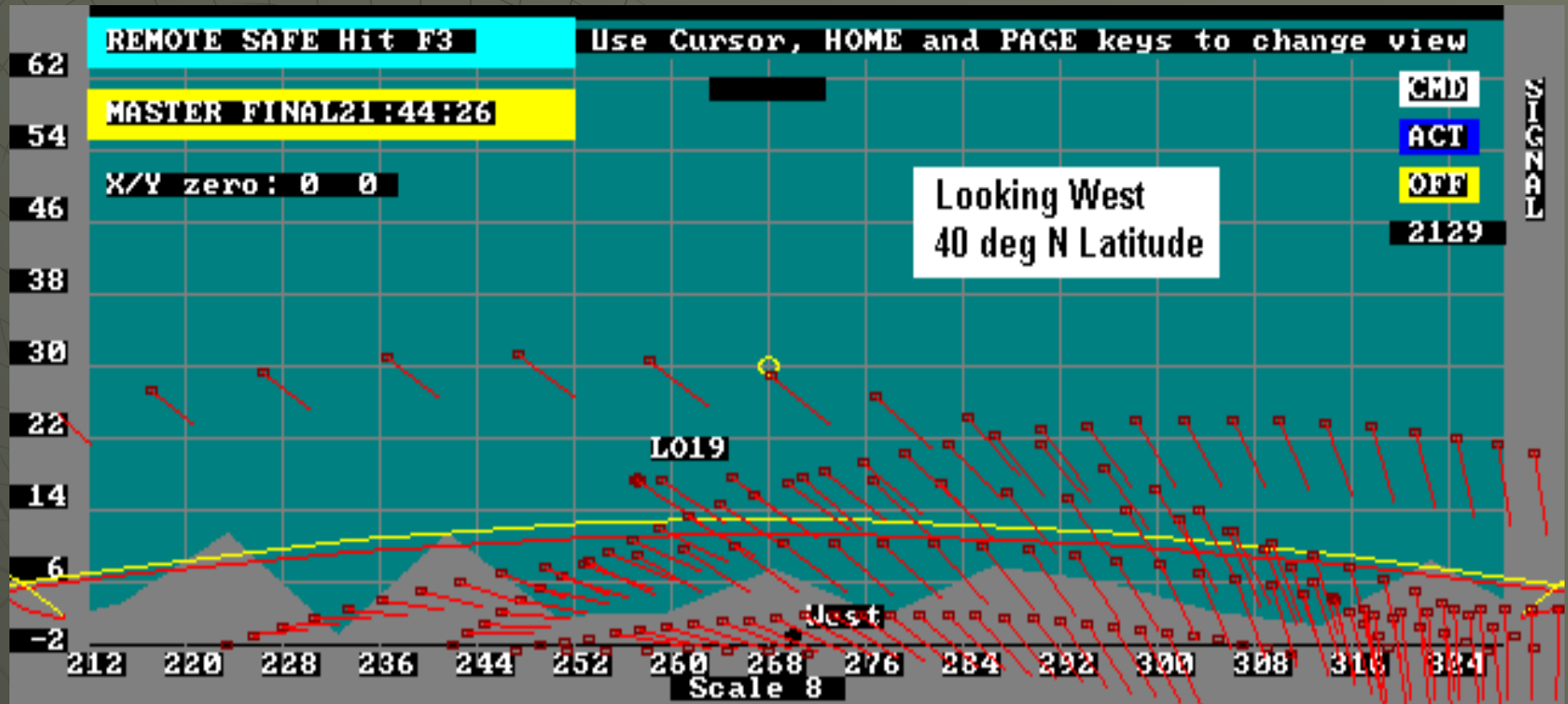


An AX.25 1200 baud APRS packet signal uses only the spectrum from about 950 Hz to 2400 Hz. Thus, there should be room for about 12 additional PSK-31 users split equally above and below. The PSK linear uplink is separate from the packet uplink and only the audios are combined on the FM downlink.

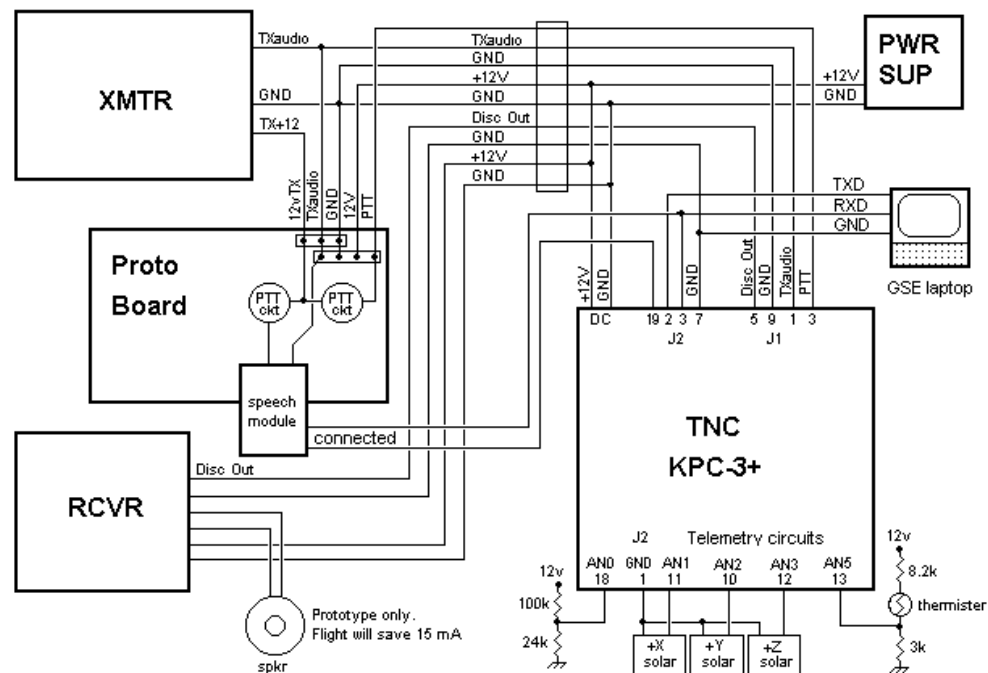
RAFT1 Internal Diagram



RAFT1 Magnetic Attitude Control



RAFT1 & MARScOm Prototype Model



Systems not simulated (to date):

PSK-31 10m uplink receiver	216 MHz NSSS receiver	216 MHz NSSS oscillator	YP-SATCOM UHF UHF AM receiver	Power	System
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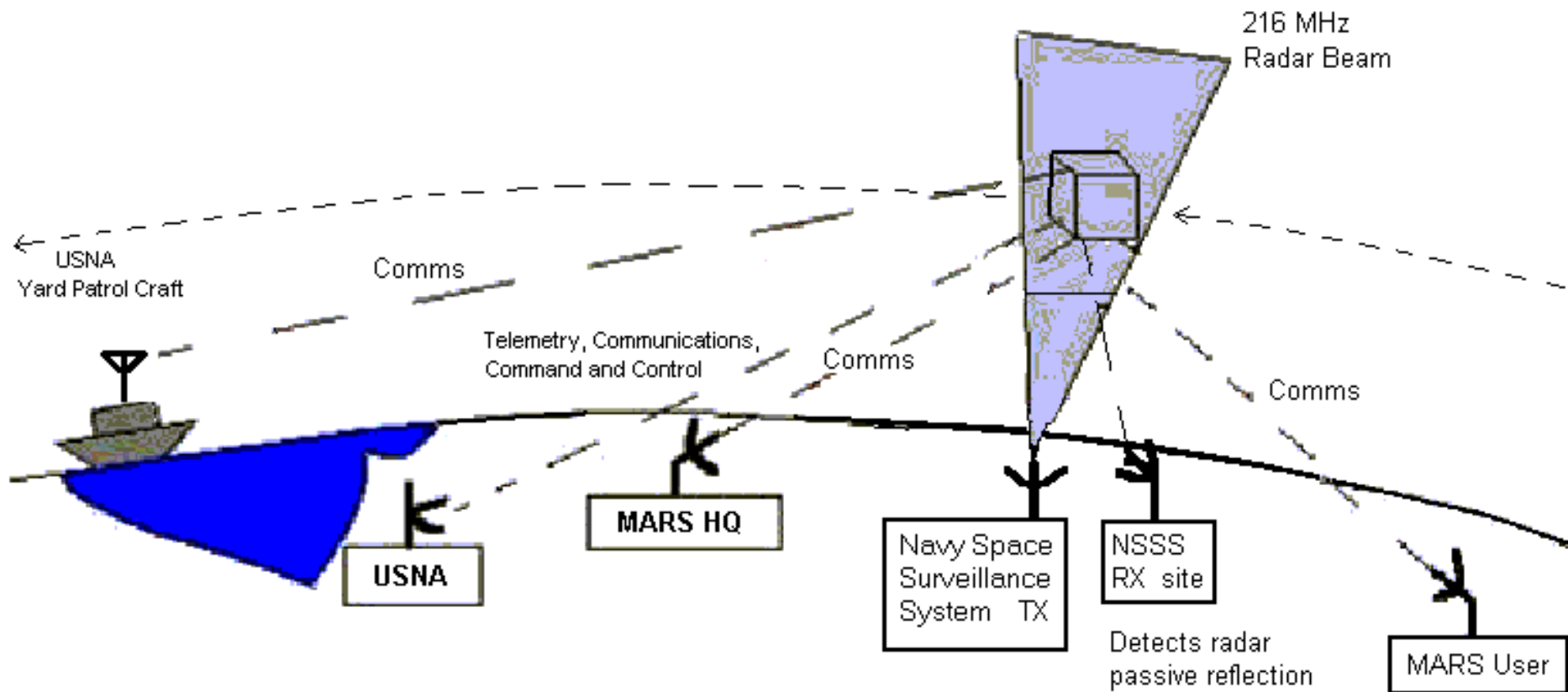
This prototype model represents the Telemetry, Command and Control system for RAFT1

- 1) This model does simulate telemetry (only 5 channels. Flight will have 10)
- 2) The TX is realistic, except that RAFT will run on 8 volts and not 12 volts requiring many mods
- 3) The RX is realistic for MARScOm on VHF, but the UHF RX on RAFT1 will draw 15 mA more current
This model includes a speaker which has 15 mA more current than flight will have
- 4) The TNC is identical to flight (though the flight will have burned in ROM defaults)
- 5) This model does not show the following circuits
 - * PSK-31 10m uplink receiver
 - * 216 MHz radar fence receiver
 - * 216 MHz radar fence oscillator
 - * MARScOm AM UHF receiver
 - * Solar charging and power conditioning

Project:	RAFT	Title:	Prototype Board
Engineer:	Midn Baker	Date:	24 Mar 2004
USNA Satellite Lab		Dwg No:	

Prototype

MARScom Mission Architecture



Military Affiliated Radio System

The Mission of the MARS system is to:

- Provide auxiliary communications for military, federal and local disaster management officials during periods of emergency or while conducting drills....
- Assist in effecting normal communications under emergency conditions.
- Handle morale and quasi-official message and voice communications traffic for members of the Armed Forces and authorized U.S. Government civilian personnel
- Provide, during daily routine operations, a method of exchanging MARSGRAMS and ... contacts between service personnel and their families back home.

Yard Patrol Craft Application



The Yard Patrol Craft

105' length

Crew of about 25

Quantity 20



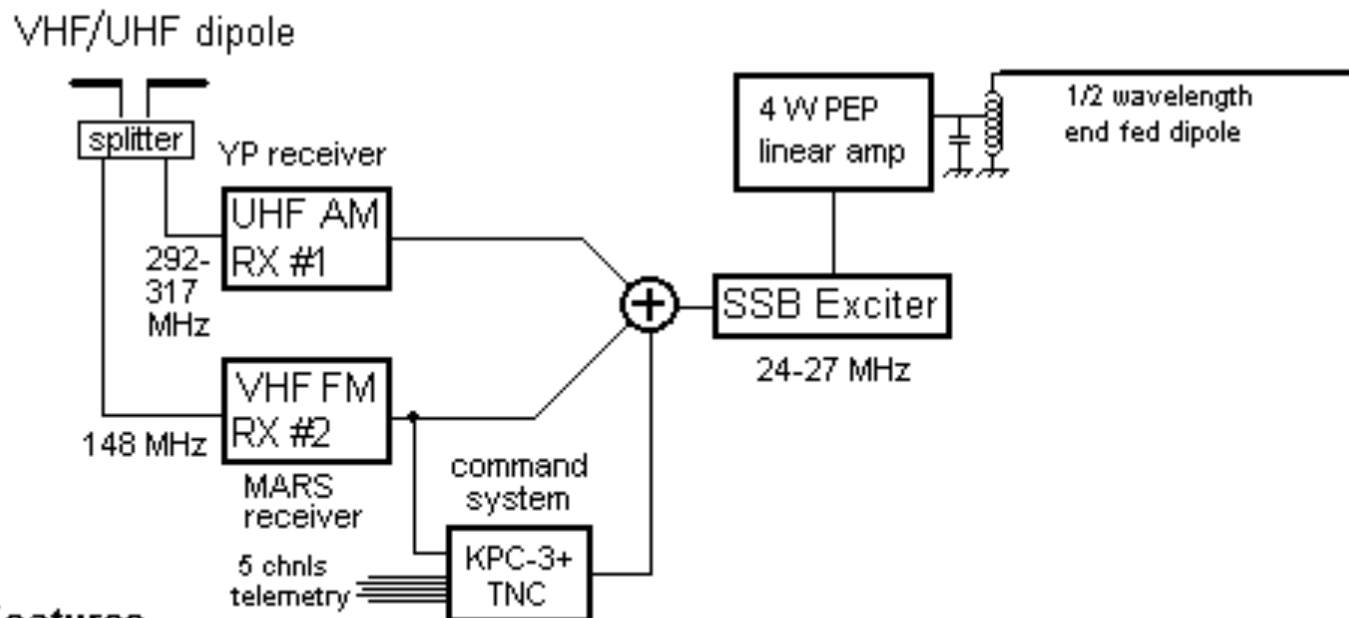
YP COMMS EQUIPMENT

→ **Tactical UHF**
(uplink)

→ **Harris HF Xcvr**
(downlink)

MARScom Block Diagram

MARScom Voice Transponder



Features

- UHF AM receiver makes MARScom compatible with ALL older UHF transmitters
- Summed dual Uplinks allow near full-duplex voice between Netcontrol and User without AGC power sharing or carrier hetrodyne
- Command receiver allows control of all three modes

RAFT Antenna Separation Mechanisms

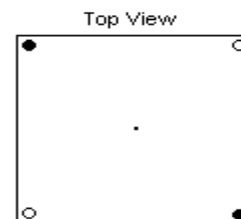


Bottom View

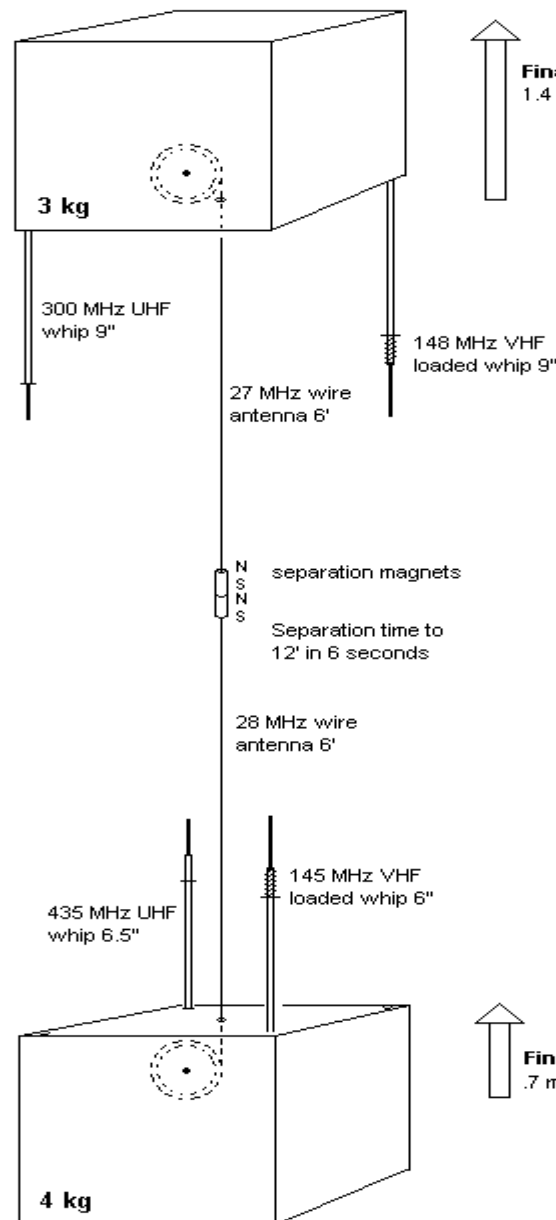
All four VHF and UHF whips are spring loaded with a spring constant of 0.25 lbf/inch.

Four inches of antenna rod is compressed into the base of each antenna. up to an extra 4.5 inches for the remainder of the antenna can be stowed inside the opposite spacecraft for the maximum deployments shown.

Each spacecraft has two whips and one long 6' wire antenna. These wire antennas unspool from a disk and at full length separate from each other with a constant and repeatable separation force between the two magnets.



Top View



pen spring
520g/.67"
1" free
.33" solid
.1 wasted

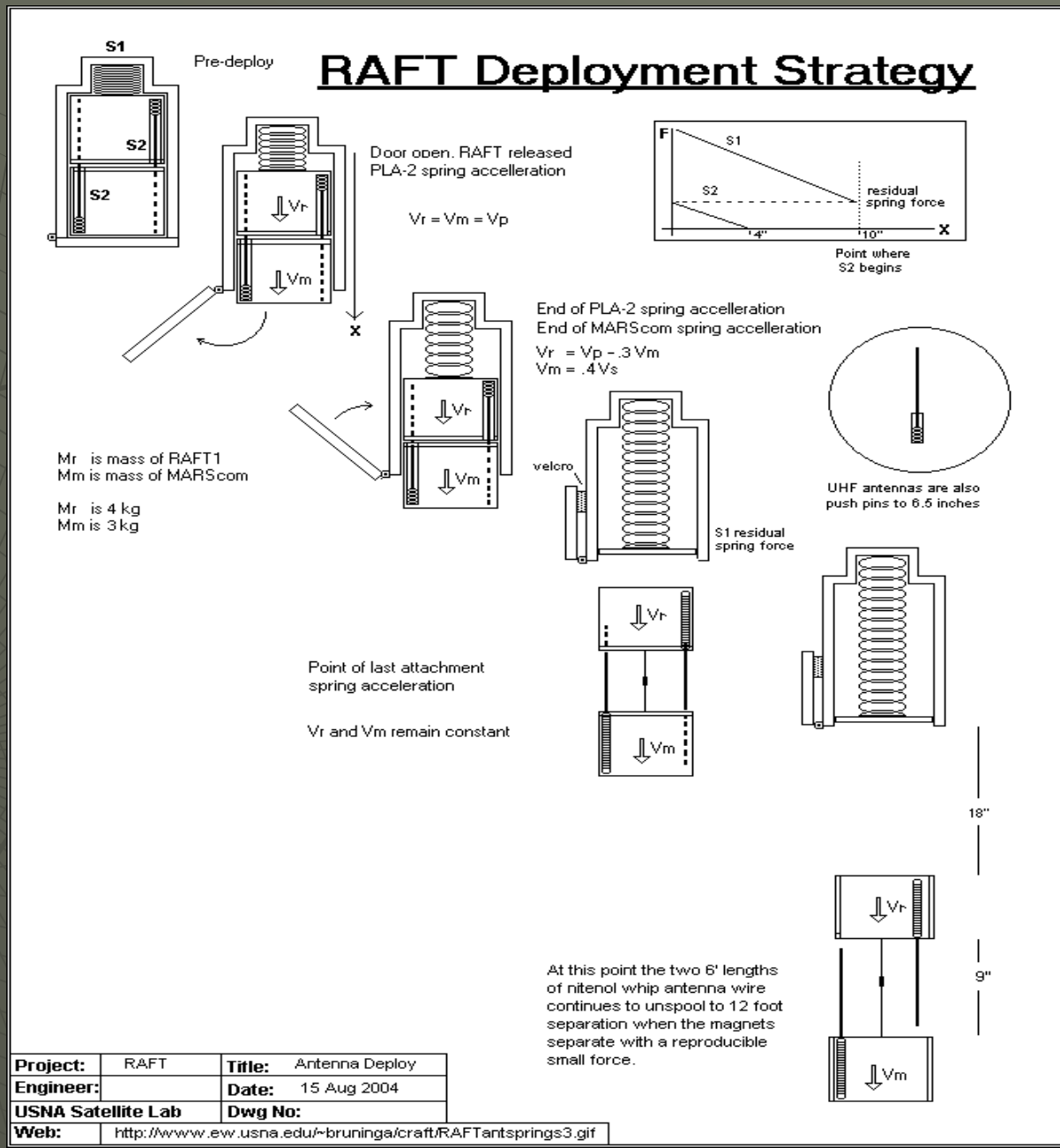
$$\frac{1}{2} K X^2 = \frac{1}{2} M V^2$$

M = 3.5 kg
K = 4 lbf/inch
V = .35 m/s

Therefore:
4kg at .3 m/s
3kg at .4 m/s

Initial Velocity
combined
1.0 m/s

RAFT Deployment



SSPL4410 LAUNCHER

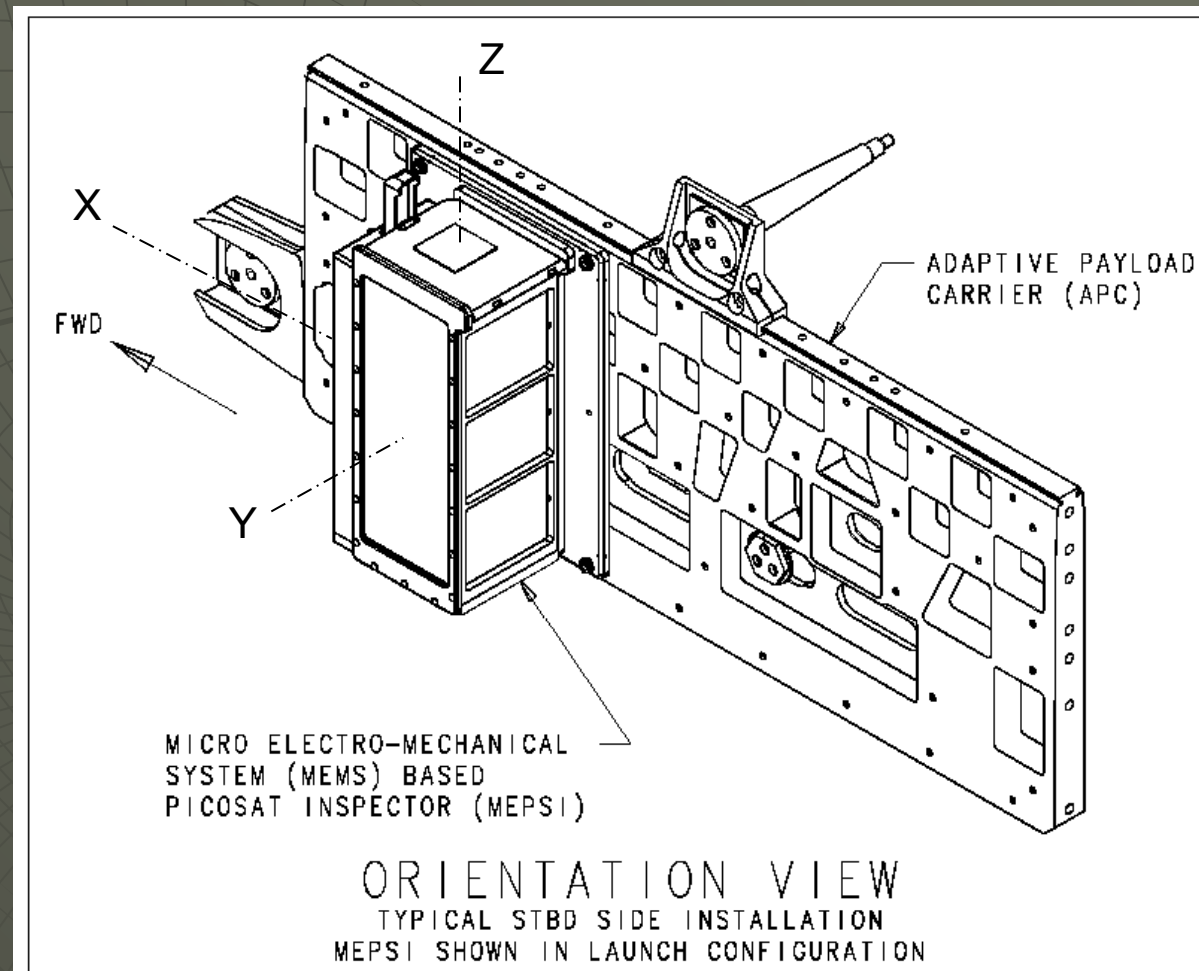


*Top Cover *, APC Adaptor **, and Latchtrain Cover *** removed in some views*



SSPL4410 LAUNCHER: Integrated Configuration

SSPL4410 LAUNCHER MOUNTED IN SHUTTLE ON APC



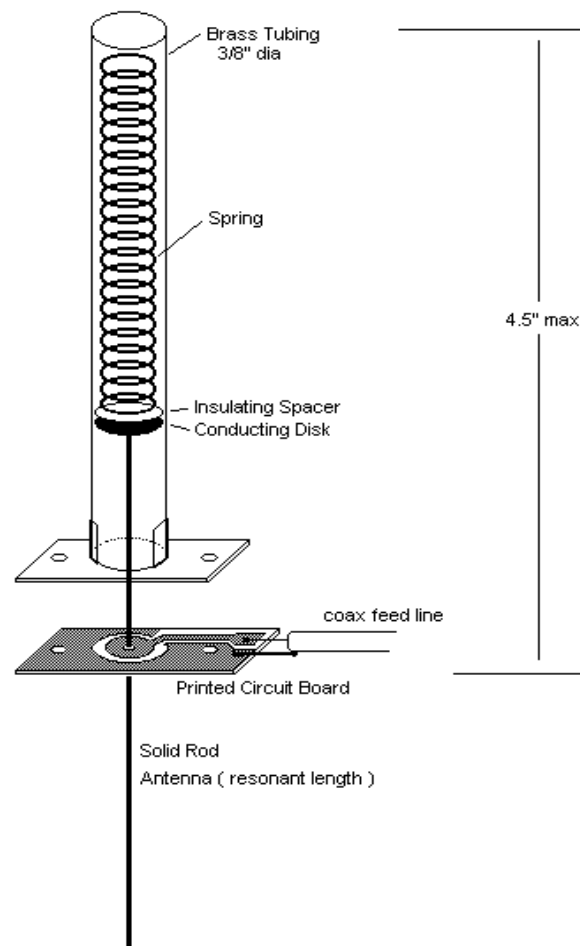
credit: Boeing

STP PICO Sat Launcher Mark II



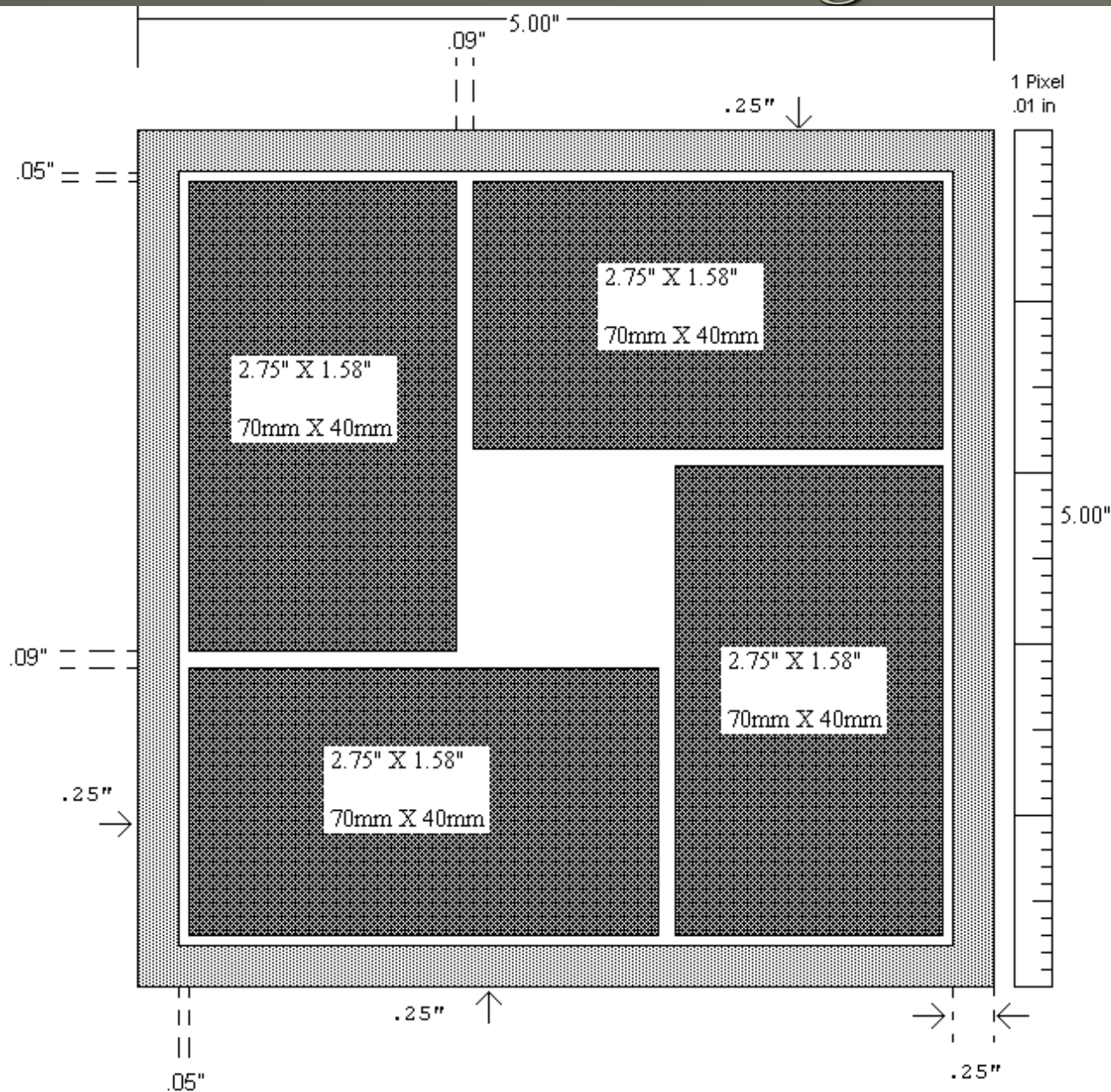
RAFT Antenna Springs

RAFT Spring Antennas and Separation Spring Assembly



Project:	RAFT	Title:	ANT Assy
Engineer:	Bruninga	Date:	19 Feb 2004
USNA Satellite Lab		Dwg No:	
Web:	http://www.evv.usna.edu/~bruninga/craft/RAFTantASSY.gif		

Solar Cell Design



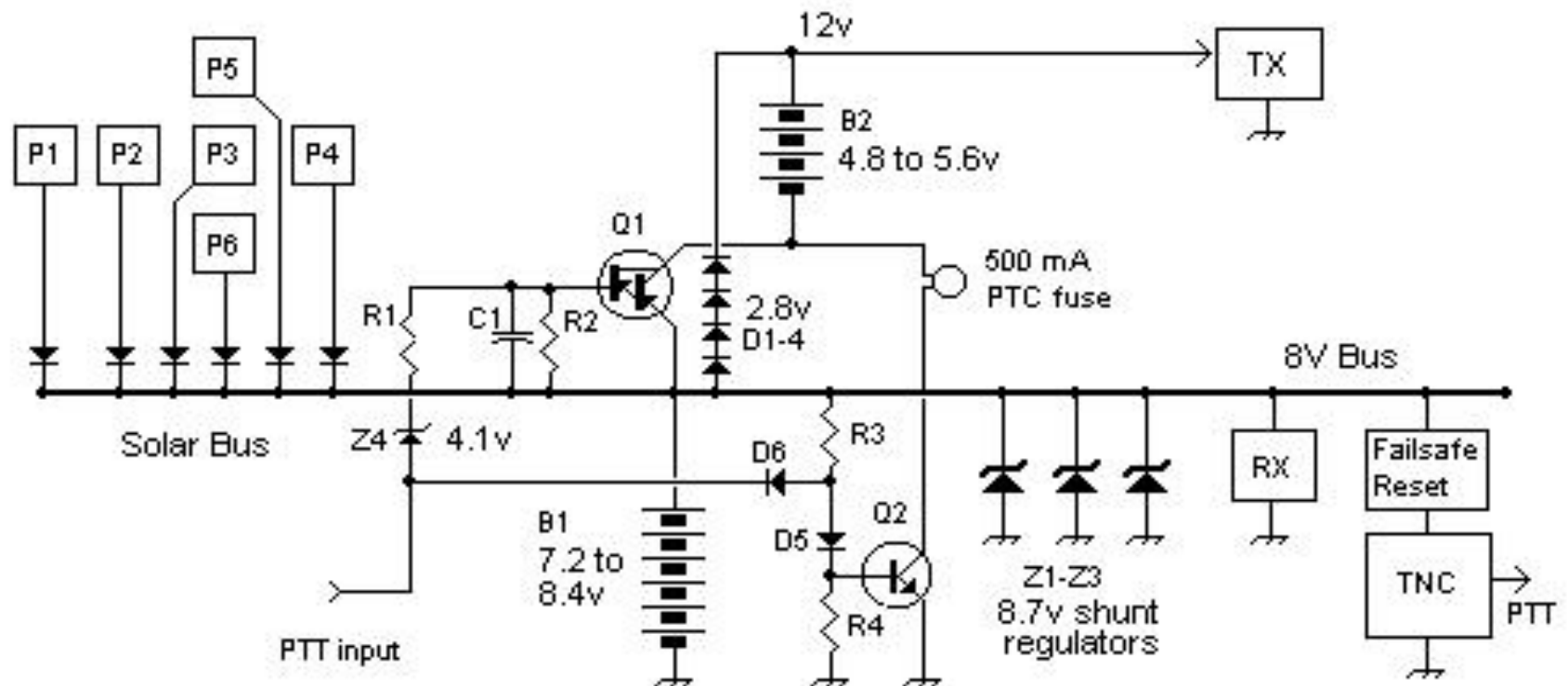
MARScom Required Power Budget

	Current (mA)	Normal	Current (mA)	YPSATCOM	Current (mA)
VHF FM RX	30.00	100%	30.00	100%	30.00
UHF AM RX	30.00	0%	0.00	100%	30.00
SSB Exciter	50.00	8.34%	4.17	8.34%	4.17
1W Linear PA	100.00	8.34%	8.34	8.34%	8.34
Decoder	10.00	100%	10.00	100%	10.00
20% Reserve	8.00		8.00		8.00
Avrg (mA)			60.51		90.51

	Normal Use	YPSATCOM	Availible
Avg (mA)	60.51	90.51	225
System (Volts)	8.40	8.40	8.4
Avg (Watts)	0.51	0.76	1.89

RAFT 8/12 V Power System

RAFT 8/12V Power System



Communication

- ◆ RAFT1 requires an IARU Request Form
 - TX: 145.825 MHz, 2 Watt, 20 KHz B/W FM
 - RX: 29.400-29.403 MHz PSK-31 Receiver
 - RX: 435.275 MHz AX.25 FM
- ◆ MARScom requires a DD 1494
 - 148.375-148.975 MHz VHF cmd/user uplink
 - 24-29 MHz Downlink
 - 216.98 MHz NSSS transponder
 - 300 MHz UHF YP Craft Uplink

RAFT Schedule

- Systems Definition complete – 15 APR 2004
- Systems Requirement Baseline – 30 APR 2004 (SRR)
- Prelim.Design Review (Internal USNA) – 15 MAY 2004
- System Design Complete – 15 OCT 2004 (CDR)
- Engineering Model Available for Testing – 15 Dec 2004
- Flight Hardware for Integration/Flight – 15 May 2005
- Launch – Sept 2005